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BY

ROBERT E. GRANT, M.D.

F.R.S. L. & Ed. F.L.S. F.G.S. F.Z.S. M.W.S. &c.

FELLOW OF THE ROYAL COLLEGE OF PHYSICIANS OF EDINBURGH, LATE PROFESSOR OF PHYSIOLOGY IN THE ROYAL INSTITUTION OF GREAT BRITAIN, AND PROFESSOR OF COMPARATIVE ANATOMY AND ZOOLOGY, IN UNIVERSITY COLLEGE, LONDON.

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LEIPSIC: T. O. WEIGEL.
1841.

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LONDON:
PRINTED BY SCHULZE AND CO. 13, POLAND STREET.

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FIRST SECTION.

Internal Organs of Excretion.

The most complicated and the most distinct of all emunctory apparatus developed in animals, are the *urinary organs*, which early appear in the animal scale and in the embryo, and exert the most immediate and extensive influence over the condition of the vital fluids, and the entire economy. Developed in the vertebrated tribes, from the cloacal end of the alimentary canal, like the lungs from the buccal extremity, the urinary, like the pulmonary organs, excrete largely the aqueous constituents with other materials of the blood, and both these complex secerning organs remove their heterogeneous products by the terminal openings of the digestive tube. As carbonic acid is the most characteristic ingredient of the pulmonary excretion, so are uric acid, or urea, and lithic acid, both abounding with nitrogen, the chief urinary products; and as the structure of no gland is yet indicative of its function, the lowest and most ambiguous forms of the urinary organs are determined rather by their general analogies of form and connections, and the chemical nature of their products, than by any peculiarity of internal structure. The urinary organs thus corresponding in function, and complimentary, to the respiratory, commonly however exhibit less tendency to ramification and vesicular dilatation in their ultimate tubuli, than the lungs and most other complex glands.

The means of respiration possessed by the simplest forms of animals, whether internal or external, may serve likewise as general emunctories for the urinary and other excretions, without the necessity of special organs for each of these products. As all parts of the body in the radiated classes of animals, the cutaneous, mucous, and serous surfaces, are constantly bathed by ciliary currents of the surrounding liquid element, the excretions may be removed directly from every point of the system without distinct organs for their elimination. The tubular, ramified, internal respiratory organs of *holothuria* (Fig. 114. *h.*), developed like renal glands from the cloacal end of the alimentary canal, and extending like the kidneys of vertebrata along the interior of the trunk, have obvious affinities, both to urinary and branchial organs, and may perform the function of both these great emunctories. Distinct isolated follicles, (Fig. 114. *i.*), however, more resembling simple urinary tubuli, are already perceptible in this animal, developed from the cloacal end of these large organs, and to which the urinary function may be confined. The calciferous gland of the asterias may have a similar function.

Although numerous salivary, mucous, and biliary follicles pour their secretions, partly excrementitious, into the alimentary canal in the helminthoid animals, no distinct formation of uric or lithic acid has hitherto indicated a urinary function in any of these simple glands. Among the entomoid articulata, many insects and arachnida exhibit, besides the ordinary biliary tubes opening into the higher chylific portion of the alimentary canal, distinct small secreting follicles or tubuli developed from the lower excretory part of the intestine, like the renal organs of vertebrated animals, and these structural analogies have been confirmed by their chemical products, by the uric and lithic acids discovered in their secretions. These simple tubuli uriniferi pour their secretion into the cloacal part of the intestine near the anus, and in some of the coleopterous insects, as in ditiscus, there is a distinct small vesicle or urinary bladder into which one or two renal tubes convey their secretion, before opening into the terminal part of the intestine. The renal tubuli were pointed out by Treviranus in the iulus among the myriapods, they have been detected in some of the crustacea, as the pagurus, and they are seen in the spiders among the arachnida. The urinary organs, like other glands of mollusca, have seldom the form of elongated isolated tubuli, as they have in the articulated tribes, but generally present the form of short wide secreting sacs, opening near the anus or the genital organs. Such sacs are seen in many conchiferous mollusca, situate in the dorsal part of the body below the heart, and opening by two short ducts along with the oviducts, near the anus; these are often charged with earthy particles, and have been generally considered as destined to secrete the calcareous matter of the valves. In several of the terrestrial and fresh-water gasteropods breathing atmospheric air by pulmonary sacs, uric acid has been detected in the secretion of a small excretory gland, laminated internally, filled with solid granules, and opening near the anus, and which thus presents a close analogy to the renal organs of higher animals. The muciparous gland of the turbinated testaceous gasteropods, pouring out so copious a secretion under the mantle, near the anus, may perform a similar office, and also the glandular sac opening near the anus in the doris and some other naked species. The poison glands of scorpions and insects, the glands for the deep-coloured excretions of certain gasteropods, the anal ink-glands of cephalopods and the muciparous glands of their oviducts, have likewise some analogies to urinary organs.

In the vertebrated classes, no organs are more constant than the two essential urinary glands, the kidneys, and the more accessory urinary bladder is one of the most variable and inconstant. The urinary organs are generally of larger size, and of a simpler internal structure, in those animals which have a limited extent of respiration, so that their bulk is commonly in the direct ratio of that of the biliary organs. The urinary organs of vertebrata, like their genital organs, are developed in the embryo from the cloacal end of the alimentary canal, and in all the oviparous tribes, they continue in the adult state to communicate directly with that cavity. The kidneys of *fishes* have a lengthened lobulated form, extending along the sides of the vertebral column as far forwards as the cranium, exterior to the peritoneum, and behind the air-sac. In their elongated form, and in their proximity to each other along the median plain, as well as in their lobed structure, and in the parallelism of their component tubuli uriniferi, they resemble the embryo-state of these organs in mammalia. They extend forwards above the heart and branchiæ, and backwards into the pelvic cavity, behind the anus, bound to the sides of the bodies of the vertebræ by the peritoneum, separated from each other by the interposed vena cava, and by the two ureters which run along their whole extent, as narrow tubes, without forming a distinct enlargement or pelvis. The great size of these emunctories of the aqueous part of the blood in fishes, may have relation to their aquatic habitat, and the quantity of fluids constantly taken with their food. The kidneys consist of subdivided ureters, the tubuli of which are variously disposed, and produce, by their subdivisions and convolutions, the lobulated exterior so constant in the oviparous vertebrata. The secreting surface of these ducts is thus greatly extended for the reception of a larger distribution of renal capillary arteries and veins over their parietes, and the different modes of distribution of the blood-vessels in the interior of these organs in the different classes, contributes to the differences perceptible in the intimate texture of the kidneys, as of other glandular organs. The tubuli uriniferi are almost always long, cylindrical, narrow, and more or less tortuous in the adult lobules of the kidneys of the plagiostomi, and the higher osseous fishes, and more short, straight, parallel, and wide, in the earlier stages of their development, and in the lowest cyclostome species. Each lobule of the adult is composed of the tubuli proceeding from a single branch of the common duct or ureter, and appears, in the embryo, to consist of a single lamina of the formative blastema. The primitive vascular blastema of the embryo divides into laminæ, and each lamina developes a cluster of tubuli, which open by a common orifice, or short duct, into the cylindrical narrow ureter extending along the whole kidney. The group of tubuli uriniferi, composing a renal lobe, are held together by the remaining portion of the soft formative blastema. The blastema at first extends undivided on the median plain, along the middle of the back, between the mucous and serous layers of the embryo; a duct for each kidney is, at length, perceived extending through it longitudinally, and giving off lateral tubuli in its course, which develope through the substance of the lobules.

In the rays and sharks, the kidneys are composed of long, fine, very tortuous and convoluted tubuli, which open separately along the course of the ureter, and in the early embryo, they appear, as in higher classes, to be accompanied with a corpus Wolffianum, composed of very minute convoluted tubuli. In the torpedo marmorata, the kidneys form two lobulated organs extending along the outside of the ureters, and consist of large tubuli, about $\frac{1}{16}$ of a line in diameter, long, and remarkably convoluted like the tubuli seminiferi of mammalia. In many of the long, equal, contorted tubuli, forming the entire mass of the kidneys in the cyprinus carpio, Muller observed a distinct dichotomous division, at some distance from their closed extremities, preserving, however, as usual in tubuli uriniferi, the same diameter throughout their entire course. The secretion of all the tubuli of each kidney is poured directly into the long narrow ureter, which, without forming a pelvic enlargement, and often without forming a urinary bladder, opens into the cloacal termination of the intestine, posterior to the rectal opening, and posterior to the genital openings, whether male or female, as in the embryos of higher vertebrata. Frequently, however, a urinary bladder is developed, which is comparatively small in fishes, its orifice then receives the terminations of the two ureters, and it opens by a short wide passage at the back part of the cloaca. The long narrow kidneys of many osseous fishes are approximated and more or less united on the median plain, without any anastomosis of their internal tubuli. In the plagiostome fishes, the kidneys are smaller and shorter, as in chelonian and other reptiles, and the ureters enter, as usual, with the vasa deferentia into a common short urethral passage, without forming a urinary bladder. The kidneys of fishes thus already present a very large secreting surface for the distribution of capillary blood-vessels, which are always much more minute than the tubuli on which they spread, as in other secreting organs. The numerous arteries which supply the renal lobes of fishes, come off directly from the trunk of the descending aorta, or from the intercostal arteries which are given off from its sides, and the renal veins mostly enter the vena cava, as it passes forwards between the lobes of these organs. The venous blood distributed through the lobes of the kidneys, by the branches of the great superior spinal vein, is received also by the vena cava, thus forming a renal portal circulation.

The kidneys in *amphibia* are less elongated and less lobulated in form than in most fishes, and the urinary bladder is of greater size and more constant in its occurrence. These glands originate early in the embryo, before the genital organs; they are developed more towards the dorsal and pelvic portion of the trunk than the corpora Wolffiana, and in the adult state they neither extend forwards to the cranium, nor backwards to the posterior end of the abdominal cavity, as they do in most fishes; so that the ureters have here a longer free course before reaching the back part of the cloaca, where they open at the sides of the wide orifice of the large urinary bladder. They are at first, as in fishes, narrow, flat, approximated laminæ, extending longitudinally along the whole extent of the abdomen, under the vertebral column, and from the periphery of the organ towards the lateral portion of each tube or ureter, numerous minute tortuous tubuli uriniferi are developed to extend the secreting surface. Their structure much resembles that of the corpora Wolffiana of birds, which were thought to be deciduous kidneys, but the kidneys are here developed much posteriorly to the situation of these remarkable deciduous glands. The kidneys retain their primitive fœtal condition to a much later period in the tritons than in the frogs and toads, and their adult form is more elongated in the perennibranchiate species, as the *proteus* and *siren,* than in those which lose the gills. The closed vesicular terminations of the tubuli are perceptible around the periphery of the soft vascular blastema, earlier than the narrow tubular necks by which they communicate with the ureters, as the development proceeds from the circumference to the centre of these organs, and the development of the ureters appears also to proceed from their renal ends backwards to their open cloacal extremities. The form of the kidneys is more elongated and narrow in the *cæcilia* and *triton* than in *salamandra* and the anurous species, and the urinary bladder of *cæcilia* is bilobate in form, like that of other caducibranchiate amphibia. The urinary bladder has a simple and elongated form in the species which retain the branchiæ, as the *axolotus, siren,* and *proteus.* The tubuli are unusually large in the adult *proteus.* The dichotomous division of the tubuli uriniferi, near their closed ends, has been observed by Huschke in some of the amphibia, and also vesicular peripheral terminations, which latter are generally confined to the earlier stages of the development of the tubuli. The small round corpuscula Malpighiana turgid with red blood, are already abundant and conspicuous in the texture of the kidneys of amphibia, as in higher classes.

In the ophidian *reptiles,* as in fishes and birds, the urinary bladder is very rarely developed, and the ureters terminate as usual, directly and separately in the cloaca. The kidneys of serpents, like most other organs of the body, partake of the elongated form of the trunk; the left is situated farther backwards than the right; they are surrounded entirely with peritoneum, and suspended freely in the cavity of the abdomen, to allow of greater motion of the vertebral column with safety, where there is yet no fixed sacrum. They have a deeply lobulated or folded structure, consisting of a long series of flat imbricated tortuous transverse lobes, or regular sinuous folds of their exterior tubulated portions, resembling externally so many small kidneys pressed closely together. The contorted and convoluted tubuli composing each of these lobes, pour their thick white viscid secretion, consisting chiefly of uric acid, by a single orifice into the common ureter, without forming a pelvic enlargement, and without the calices developed in the more concentrated forms of the kidneys of mammalia.

The narrow tubular ureters follow along the inner margin of the kidneys, receiving successively the short wide common ducts of all the separate lobes, and open by distinct orifices into the back part of the cloaca, as in other oviparous vertebrata, whether provided with, or destitute of, a urinary bladder; sometimes, however, a small vesicular dilatation is formed on each ureter before it opens into the cloaca. The blood-vessels penetrate from the exterior of the kidneys between the lobes, and appear to have been mistaken by Huschke for tubuli uriniferi ramifying through the lobes. The affinity of the anguine serpents to saurian reptiles, so obvious in most parts of their structure, is seen also in the presence of a urinary bladder in these species, which is of considerable size in the pseudopus ; and the two short kidneys of the anguis are placed on the same transverse plain of the body, as in higher reptiles. The small white tortuous tubuli uriniferi preserve the same size and diameter throughout the substance of each lobe, and the same tortuous diverging course to their periphery, so that there is yet no distinction of cortical and medullary portions of these organs, as is seen in the kidneys of mammalia. In the long narrow kidneys of the embryo, the tubuli are short, cylindrical, and straight, and extend separately from the ureter, through the soft blastema, with little regularity in their arrangement or in their course; they commence in the embryo earlier than the suprarenal capsules, near to the cloacal end of the trunk, on the dorsal side of the corpora Wolffiana, as two narrow white opaque bands of blastema, along the inner edges of which, the ureters and the rudimentary tubuli make their appearance. Their distance from the cloaca increases, the ureters elongate, especially that of the right side, a lobulated or convoluted surface is developed, the ureters open into the cloaca, close to the ducts of the deciduous kidneys or corpora Wolffiana.

In the saurian reptiles there is more generally a urinary bladder, and the kidneys are less elongated, and situated farther backwards in the pelvic region of the trunk, than in ophidia. In the crocodiles, however, and some others, where there is no urinary bladder, the ureters open separately into the dorsal part of the cloaca, as in birds and many inferior vertebrata. And even where there is a urinary bladder in the sauria, the ureters do not open directly into its cavity or fundus, as they do in most mammalia, but into the dorsal part of the cloaca near the neck of the bladder, as is seen likewise in fishes amphibia and chelonia. The great size of the urinary bladder in these animals results from its containing the entire allantois, which is not protruded from an external umbilicus, nor constricted and obliterated to form a urachus as in mammalia. The kidneys of the crocodilian sauria are surrounded with tortuous superficial folds, and appear more deeply lobulated externally, like those of serpents, and from the ureters sending off numerous lateral ducts, they are more complicated in the internal arrangement of their tubuli, than in the lizards. Their tubuli uriniferi, however, do not form tortuous groups arising from short wide primary ducts, in each of the several lobes, as in serpents, but diverge regularly in straight radiating lines from around a central wide duct, which traverses the whole extent of the axis of each lobe; so that a vertical section of a part of one of the lobes presents a pinnate appearance, with parallel straight tubuli extending to the periphery from the central duct. The kidneys are more developed at their anterior part in some of the lizards, as they are in birds, and taper backwards to their posterior ends, being shorter in sauria than in ophidia, and longer than in chelonian reptiles. In the embryo, the kidneys are more elongated, as in serpents, and their short simple tubuli extend directly from the side of the ureter, without indication of the lobulated structure seen in the adult lacertæ.

The kidneys of chelonian reptiles have a more concentrated and shorter form, and are less distinctly lobulated than in most inferior vertebrata; their surface presents a convoluted appearance, as in crocodiles, from the tortuous forms of their component lobules. The tubuli uriniferi are more tortuous in their course in the chelonian than in the crocodilian reptiles, but arise in a similar manner from the ramified ureters. Their urinary bladder is of greater size than in any other vertebrata, which accords with their succulent vegetable nutriment and their limited cutaneous perspiration; generally it is partially divided into two, and sometimes into three lobes at its upper part. Like the respiratory allantois of the fœtus of higher classes, it is a great follicular or hernial development from the cloacal part of the intestine, and although, as usual in oviparous vertebrata, the ureters do not terminate directly in it, but behind its cloacal orifice, uric acid is found in its viscid contents, as in the similar large urinary bladder of the batrachian animals.

The kidneys of *birds* are still constantly and deeply divided, especially at their posterior ends, into numerous lobes of considerable size, covered on their ventral surface only with peritoneum, and lodged immediately behind the lungs in the deep fossæ along the sides of the sacrum. They are elongated in form, diminishing in size from before backwards, constricted in their middle, symmetrical, placed between the same transverse plains of the body, deeply sulcated on their dorsal surface by the transverse processes of the sacrum. The component lobes are most numerous and distinct in the ostrich, and least apparent in some of the palmipeds, as the pelican. The largest anterior lobe of each kidney receives a distinct renal artery from the trunk of the aorta, and the smaller succeeding lobes receive branches from the femoral arteries, or from the sacra media prolonged from the aorta. The surface of the lobes, when closely examined, presents a convoluted appearance, as in many reptiles, from the tortuous distribution of the small lobules, formed by the shut ends of the ultimate tubuli uriniferi, as shown by Ferrein, and tufts of these tubuli end in small calyces, as in mammalia. The simple narrow ureters collecting the secretion from the renal lobes, and extending along the ventral and inner surface of the kidneys, without forming a pelvis, open directly into the dorsal and lateral part of the cloaca, by two prominent papillæ, and, there being no urinary bladder in birds, the urine, containing a large proportion of urea with little aqueous constituents, is mixed with the other excretions in the cloaca. The openings of the ureters thus preserve the same relative situation as in reptiles and lower vertebrata. But in the ostrich, which presents so many other affinities with the mammalia, the two ureters open at the lower margin of the large cloacal cavity, which allows the secretion to accumulate as in a distinct bladder. The bladder, indeed, in its most normal form, is only a development of the cloacal part of the intestine, and the want of a urinary bladder in adult birds, is due to the extent of obliteration of the allantois and urachus originally continued from their cloaca. The minute cylindrical uriniferous tubuli, much larger than the capillary blood-vessels, and directed in a pinnate manner to the surface of the renal lobules, leave perceptible interlobular spaces for the blood-vessels, as in other glands, and the small sanguineous vesicles, or corpuscula Malpighi, are seen on these vessels in the tissue of the organ, as in mammalia. The larger branches of the uriniferous ducts unite to open by prominent papillæ into the ureters, and small calices were already detected by Ferrein in the pigeon, and are seen in the kidneys of the cassowary, the falcon, the pintado, and other birds.

The kidneys of birds first appear in the embryo as a soft transparent, almost homogeneous mass, in which the convoluted and foliated structure is gradually evolved, and the extremities of the uriniferous tubes which compose the lobules become perceptible in the periphery of the vascular blastema. For some days after escaping from the egg, in the larger birds, the delicate convolutions on the surface of the renal lobes, and the elegant pinnate arrangements of the ultimate tubuli, are beautifully manifested to the naked eye, by means of the natural secretion of white inspissated urea which fills and distends all these parts ; but by immersion in alcohol, this beautiful appearance is soon effaced, by the uniform whitening of the whole surface. These organs are preceded in their development by the two elongated follicular glands, the corpora Wolffiana, the ducts of which proceed likewise along with the ureters to the cloaca. The deciduous corpora Wolffiana, composed of simple tortuous follicles proceeding transversely from their common marginal duct, and extending along each side of the vertebral column, precede much the development of the kidneys, and disappear before the bird escapes from the ovum: they are more connected with the evolution of the genital glands, the testes and ovaria, than of the urinary organs, in the classes where they are observed. As in other glands, the tubuli of these deciduous bodies appear at first as pedunculated peripheral vesicles, which become gradually elongated and constricted to form straight narrow tubes, and, at length, long narrow tortuous and interwoven tubuli extending to the interior edge of the organ from the exterior marginal duct. Their structure resembles that of the kidneys of amphibia, but they are not organically connected with the urinary tubuli, and appear to assist in the development of the genital glands.

The urinary organs of *mammalia* generally present a more compact and simple external form, and a more extensive secreting surface by the minute divisions and the compact arrangements of their tubuli, than in lower vertebrata; they eliminate a larger proportion of the aqueous constituents of the blood, and they are always provided with a distinct urinary bladder. The lobed condition of the kidneys, so constant in lower classes, is still, however, observed as a normal adult character in many of the inferior mammiferous tribes, as in the cetacea, many ruminating and pachydermatous herbivora, the slow-moving plantigrade carnivorous quadrupeds, and in the amphibious mammalia and the otter. In the higher tribes, the kidneys pass early from the primitive lobulated condition to a more concentrated form, by the union of the lobes into a single compact organ, which generally presents internally a distinct cortical and medullary portion, resulting from the straight and parallel course of the minute tubuli in the central part, and their tortuous interwoven course in the exterior portion. These two portions are alike perceived in the separate renal lobes of the human fœtus, and in the component lobes of the adult lobulated kidneys in lower mammalia. The right kidney is generally more advanced in the trunk than the left, and impresses the liver; they are covered only on the ventral surface with peritoneum; they present a depressed and rounded form more or less elongated in different species, and they are largest and most divided into lobes in the aquatic and the larger terrestrial forms of this class. In several of the cetacea, there are more than two hundred deeply isolated lobes in a single kidney, but in the monotrema, they are united into a simple compact organ; in the lobulated kidneys, the number of papillæ and infundibula corresponds with the number of lobes, but in the compact forms of the organ, the number of these conical tufts of tubuli is often reduced to a single papilla, and the entire pelvis to a single calyx. The relative development of the cortical and medullary portions, varies as much as the outward form of the organ in different mammalia. The structure and relations of the straight and tortuous tubuli uriniferi of the simple and lobulated kidneys of mammalia and lower vertebrata, and the connections of the small round vascular corpuscules with the arterial branches, were already investigated and described by Malpighi.

The kidneys of mammalia, as of lower vertebrata, are preceded in the embryo by the corpora Wolffiana, composed each of elegant series of simple transverse tubuli opening into a common longitudinal duct, which extends along the outer margin of these deciduous glands and terminates in the cloacal end of the intestine; these bodies are interposed between the situations of the renal and genital glands, they are most developed long before the middle of fœtal life, and they have entirely disappeared before birth. The kidneys appear at first as consisting each of a congeries of minute tortuous follicles radiating to the periphery of a small round soft gelatinous blastema, and terminating around the exterior surface of this primitive mass in minute closed pyriform sacs, like the vesicular terminations of the bronchial tubes of the lungs or of the early tubuli of most other glands. The peripheral terminal vesicles diminish in size and disappear, as the tubuli become lengthened, tortuous, and interwoven, and there is no trace of distinction between cortical and medullary portions in the interior, nor of lobes on the surface. The tubuli in the central part of the kidney become, at length, more straight and parallel, and grouped into conical fasciculi, which compose the medullary portion, while the tortuous interwoven peripheral parts of the tubuli form the cortical portion of the organ. These conical groups of straight converging tubuli meet at their open extremities, and terminate, as shown by Malpighi, in prominent papillæ, which are surrounded by calyces opening generally, by infundibula, into a common wider receptacle, or pelvis, from which the ureter commences. The tubuli often divide dichotomously, both in the medullary and the cortical part of the kidney, without changing their diameter. The development of the ureters in the embryo, begins from their renal ends and proceeds downwards, being at first solid, then tubular, then opening into the bladder, which, in some abnormal cases, they do not reach. The urinary bladder is developed from the cloacal end of the intestine, as the peduncle of the allantois and the urachus, but its early communication with the alimentary canal is at length entirely cut off in most mammalia, by the separation of the rectal portion of the intestine above from the uro-genital canal below. In the monotrema, however, they continue to communicate, as in reptiles, through the whole of life.

Many internal secreting glands already considered, may likewise be viewed as partly internal excretory organs. The internal tubuli and cells of the lungs, by the carbonic acid and aqueous part of the blood which they so largely eliminate from the system, may be regarded as presenting an extended internal excretory surface; and from the composition and functions of the bile, the tubuli of the liver may be viewed nearly in the same light. The various kinds of odorous and poison-glands at either end of the alimentary canal, and even the muciparous glands throughout its entire course, have partly an excretory function. The surface of all mucous membranes lining internal ducts and cavities which communicate externally, and serous membranes lining closed cavities, even the interior lining of blood-vessels, by constantly excreting and detaching globules, cytoblasts, or scales of epithelium, may also be considered as exerting an excretory function on the circulating fluids of the body.

SECOND SECTION.

External Organs of Excretion.

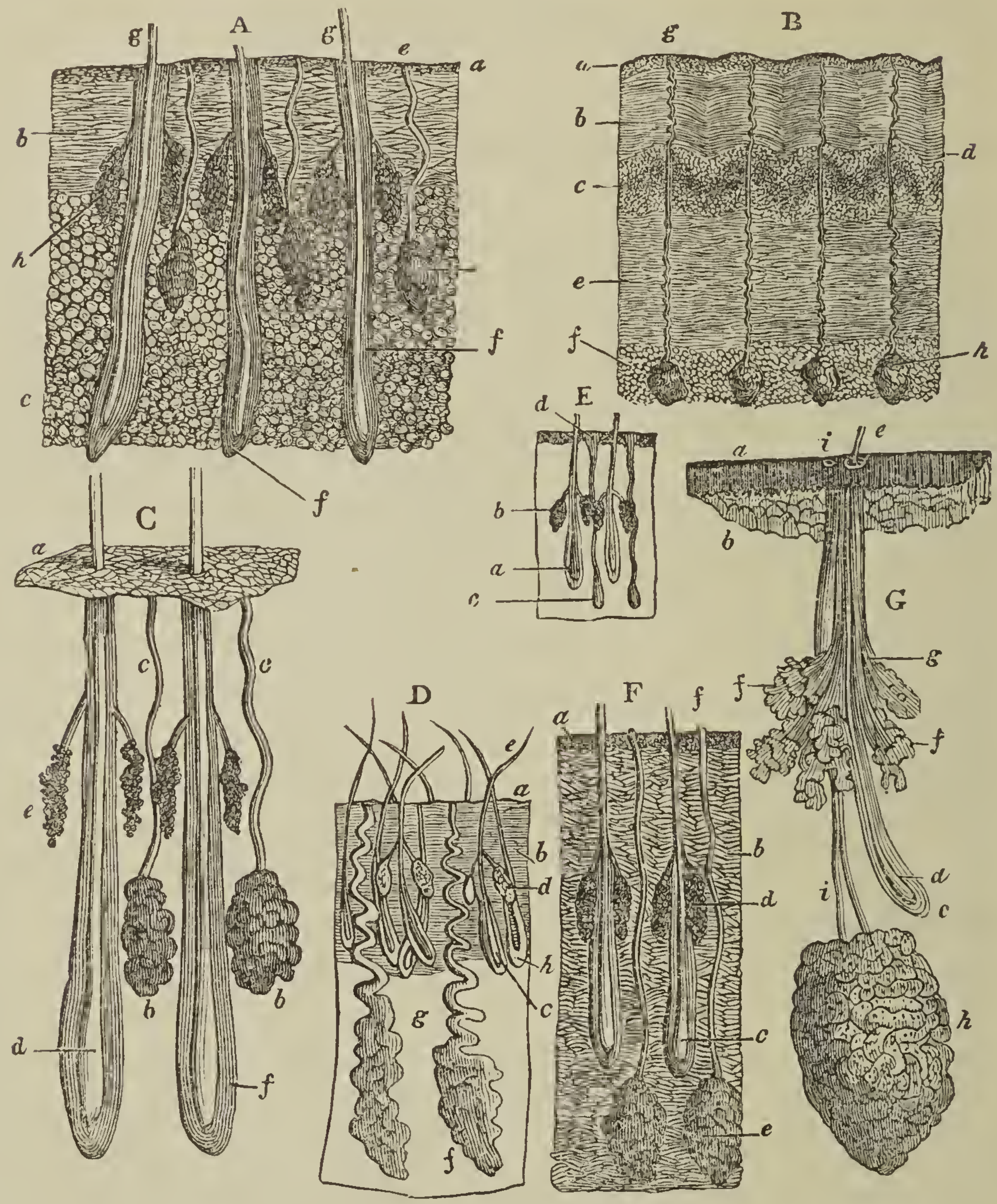
As the larger and more complex internal excretory organs are developed from the common mucous lining of the digestive canal of animals, the smaller and more numerous external forms of these organs are developed from the cutaneous covering of the body. The naked surface of the skin in most of the lowest animals, being both respiratory and secerning, may likewise be regarded as a general excretory surface, and the various forms of extravascular scales, shells, and other epidermic materials, poured out as nuclei or in a fluid state from its capillaries, and growing or concreting into granules, cells, or cytoblasts, have also a close analogy to excretions. The subcutaneous muciparous glands so large and complex in fishes, and so numerously spread over the naked surface of amphibia, and various other cutaneous glands of higher animals, eliminating materials little subservient to individual nutrition or to the race, are partly excretory in their function. The cutaneous glands most special and distinct in their excretory function, and the product of which is most analogous to the urine of the kidneys, and the carbonic acid and halitus expired from the lungs, are the small, simple, convoluted, *sudoriferous follicles*, or sweat-glands, perforating the epidermic layers, and so numerously spread over the entire surface of the body in the warm-blooded vertebrata. The innumerable minute ramified sebaceous glands, which pour their oily secretion, by distinct ducts, into the wider cutaneous follicles for the hairs, to lubricate and protect the skin and its epidermic developments, may likewise be considered as partly cutaneous emunctories, eliminating the oleagenous materials of the blood; so that these external forms of excretory organs become almost essential constituents of the cutaneous or tegumentary parts of animals.

CHAPTER EIGHTH.

TEGUMENTARY ORGANS.

The animal body being an aggregate of numerous complicated and delicate apparatus, nicely adjusted to the various mechanical and chemical functions necessary for the support of life, is always protected externally from the action of the surrounding elements and from accidental injuries, by some common investing *tegumentary organs*. These external investments consist generally of a compact reticulate fibrous, elastic, highly sensitive and vascular *cutis*, corium, or true skin, and a more superficial, extravascular, insensible, scaly *cuticula*, epidermis, or scarf-skin; and to these are often superadded various forms of horny scales, plates, spines, hairs, feathers, or other accumulated epidermic exudations from the vascular secreting surface of the true skin. The cutis or true skin of the higher classes of animals, developed, like the osseous, the muscular, and the nervous systems, from the exterior or serous layer of the germinal membrane of the ovum, continues in the adult as the most exterior of the sensitive and vascular tissues of the body. It is not only the seat of the sense of touch, by the innumerable sensitive vascular and erectile papillæ developed over its surface, but likewise of various secretions from myriads of minute glands imbedded in its substance, and whose ducts traverse in a straight or tortuous direction its fibrous tissue. These ducts open on the surface of the epidermis, as seen in the annexed views (Fig. 146.) from Gurlt, of the simple *piliferous follicles* (146. A. C. *f. f.*) and the more complex *sebaceous glands* (146 A. *h.* C. *e.*) and *sudoriferous glands* (146. A. *d.* C. *b. b.*), communicating with the exterior surface of the skin (146. A. B. C. *a. a. a.*). Besides the piliferous follicles, the sudoriferous and oil-glands, and the numerous capillary blood-vessels, nerves, and lymphatics which every where permeate the fibrous texture of the skin, it has been considered as the seat of a distinct *chromatogenous* apparatus for secreting the carbonaceous colouring matter or pigment-cells of the

Fig. 146.



epidermic scales, and of distinct *blennogenous* glands for secreting the constituent matter or cytoblasts of the epidermis itself.

Resting immediately on the subcutaneous cellular and adipose substances (146. A. *c*. B. *f*.) is the inferior fibrous reticulate layer (146. A. *b*. B. *e*.) of the cutis, of very variable thickness in different animals, permeated by the subjacent cellular substance, and in which are generally imbedded the minute oil-glands (146. A. *h*.) of the piliferous follicles (146. A. *f*.) which contain the hairs (146. A. *g*.). The exterior papillated layer (146. B. *c*.) of the cutis is more thin, compact and homogeneous, covered with sensitive papillæ, traversed by the piliferous follicles, the hairs, and the long tortuous ducts of the sweat-glands (146. B. *h.*), and is in contact with the rete mucosum (146. B. *d.*) of Malpighi, or the soft inferior layer of epidermis. The prominent conical sensitive papillæ of the surface of the skin are most developed on the naked palmar and plantar surfaces of the hands and feet in the soft-footed animals, as seen on the palm of the human hand (146. B. *c.*); and on many parts of the skin they are not perceptible, as on the human scalp (146. A. *a.*).

The *sudoriferous* glands have been detected by Gurlt in all parts of the surface of the body, placed generally deeper than the piliferous follicles, and imbedded in the subcutaneous cellular substance. They are large and obvious to the naked eye, beneath the soft skin of the genital region of the horse (146. G. *h.*), and nearly as large under the plantar surface of the dog's foot, and they are of smaller size in other parts of the hairy skin of the horse (146. F. *e.*), and in the skin of the hog (146. C. *b.*). They are small and round in the palm of the human hand (146. B. *h.*), more elongated in the human scalp (146. A. *d.*), minute, simple and uniform under the skin of the ox (146. E, *c.*), and under the hairy skin of the dog, and they are very large and equal under the thin soft skin of the sheep (146. D. *f. g.*). They consist each of a single transparent long follicle, more or less convoluted into a mass at its closed extremity, like the tubuli of the testis, and their single tortuous duct, lined with epidermic cytoblasts or epithelium, opens by a dilated conical orifice on the surface of the skin (146. A. *e.* E. *d.*), or continues its spiral windings (146. B. *g.*) through the strata of thickened cuticle (146. B. *a. b.*).

The small elongated racemose clusters of minute transparent white follicles, composing the conglomerate *sebaceous* glands (146. A. *h.* C. *e.*), are situate more superficially in the texture of the skin, than the piliferous follicles (146. A. C. *f. f.*) or the sudoriferous glands (146. A. *d.* C. *b.*), which extend more deeply into the subjacent cellular substance. The sebaceous glands and the piliferous follicles occur over most parts of the body, excepting on the naked palmar and plantar surfaces of the hands and feet in man and carnivora, where neither are observed. In some naked parts of the skin the sebaceous glands abound without piliferous follicles, but the piliferous follicles, when present, are always accompanied with one or more, generally with two, sebaceous glands. The numerous small follicles composing each of these conglomerate sebaceous glands, communicate generally with a single duct, sometimes with several ducts, which open directly into the piliferous follicles, where they are present, or on the surface of the skin in many hairless parts; and these glands vary in magnitude generally according to the size of the hairs they accompany, but they are very minute in the hog (146. C. *e.*) which has large hairs (146. C. *d.*).

The *piliferous* follicles (146. A. C. *f. f.*) are appropriated to the development of the hairs, and to the reception of the oily secretion of the sebaceous glands. They are elongated simple sacs, widest at their deeper closed extremity, and narrowest at their orifice, where they embrace closely the contained hair. They penetrate vertically through the skin to the subcutaneous cellular substance, and they correspond in size and form with the contained hair. They are prolongations of the vascular secreting surface of the cutis, and they receive the secretions of the sebaceous glands, which can be pressed out from their orifice. Like all the ducts of cutaneous glands, they have a distinct lining of epithelium, which can be drawn out entire, continuous with the epidermis, from the macerated skin of the fœtus, and coloured portions of the cuticle can often be distinctly traced into their cavity. The epidermic linings of these various small cutaneous ducts, appear as so many minute connecting fibres, when the cuticle is being gradually drawn off from the surface of the cutis.

The most exterior continuous tegumentary layer of animals, as of other organized bodies, is the insensible extravascular *epidermis*, poured out as granular nuclei in a fluid medium, from the reticulate, vascular, sensitive surface of the cutis, or secreted by its capillaries. Like most internal organized tissues, the exterior epidermic covering originates from minute cells, or *cytoblasts*, which possess, like entozoa, an independent means of growth, and undergo various changes in the course of their development; and all the different cuticular appendages, as hairs, spines, nails, hoofs, horns, feathers, and scales, are merely aggregations of the same epidermic cells. The epidermic *nuclei* when first formed, exhibit internally a granular structure, and are contained in a soft gelatinous connecting substance, a *cytoblastema,* which enables them to grow, and to detach concentric layers or enveloping cells from their surface. The exterior cells grow more rapidly than the contained nuclei which first developed them, and there are commonly minuter pigment-cells, like internal parasites, free in the contained fluid of these cytoblasts. The soft, round, loosely aggregated, newly produced, growing cytoblasts, forming the lower strata of epidermic cells, compose the *rete mucosum* of Malpighi, where the various hues of the contained pigment-cells, in all deeply-coloured animals, are most fresh and intense, and where the cuticular cells are still most agglutinated to the surface of the cutis. As the epidermic cells, by their own independent vitality, enlarge, and thicken in their parietes, the connecting gelatinous matter, or cytoblastema, disappears, they become contiguous, compressed, and polyhedral, and the nuclei are still perceptible towards the centre of the thus flattened cells, attached to their interior surface. In the outer strata of the epidermis, the cells are thin, empty, flattened disks, bleached, deprived of their colouring matter, compressed into a continuous layer, and they at length fall from the surface as dried, isolated scales, with their opposite parietes coherent, and with single persistent nuclei. The black pigment-cells of the cuticle of the tadpole, undergo remarkable changes of form, like a polygastric *proteus,* and they contain numerous, minute, parasitic, spontaneously moving cells, in their interior.

The epithelial cytoblasts of internal parts present similar phenomena of growth, development, and metamorphosis, to those of the exterior epidermis; they are seen on the lining membrane of the heart, in veins, on the chorion, the amnion, and on all mucous and serous surfaces; their form is sometimes lamellar, sometimes conical or cylindrical, and they often exhibit distinct vibratile cilia at their free extremity on mucous membranes. Cytoblasts abound in all secretions, they constitute the first rudiment of the ovum, and the globules of blood, milk, and other animal fluids; they give origin to capillary vessels, to cartilage, to the fibres of the lens, of the teeth, of cellular tissue, of nerves, muscles, and most other tissues of animal bodies. The primitive germinative nuclei often develope two or more concentric enveloping cells around each, these concentric spheres often coalesce and unite to thicken the parietes of the general cell, two or more nuclei are often found within the same cell, and the nuclei generally retrograde in their development, or entirely disappear, when the cells they produce have arrived at their maturity.

The successive strata of epidermic cytoblasts are most accumulated, and retained, in a condensed form, on parts of the skin most exposed to pressure and friction, as on the palmar and plantar surfaces of the extremities, and on the whole surface of thick-skinned naked animals, as rhinoceroces, hippopotami, manati, and other pachyderma and cetacea. The difference of colours in the contained parasitic pigment-cells of the epidermic cytoblasts, which are most vivid and most lively in the soft, loose cytoblasts of the rete mucosum, gives rise to the varied hues of all the tegumentary parts of animals. In the interior even of these parasitic pigment-cells, are sometimes seen numerous other minute cells in active movement. The colour of the pigment-cells often varies in different parts of the skin, giving rise to corresponding differences in the colour of the hairs, spines, and other epidermic developments; their excess produces the intense colour of the rete mucosum of the negro, and other deeply-coloured animals; their deficiency produces the various tegumentary peculiarities of albinos; and the ephemeral existence of these coloured parasites, causes the outer strata of epidermis to be shed colourless, from the most deeply coloured skins of animals, as salamanders, serpents, and negros. The epidermis is already a thick layer on the palmar and plantar surfaces of the extremities in the early condition of the embryo, and the coloured parts of the integuments of quadrupeds are distinctly marked at an early period of the fœtus in utero.

The cytoblasts of the epithelium, at the exterior openings of mucous cavities, have mostly the same flattened form and stratified arrangement as in epidermis, as seen on the interior of the nostrils, the lips, the mouth, the tympanic cavity and the mastoid cells, and on the surface of the conjunctiva and cornea, where they were observed and described by Leuwenhoek, as forming a hundred strata of superimposed scales; but in most other parts of the mucous surfaces they present a conical or cylindrical form, are compactly arranged with their long axes vertical to the surface on which they rest, and have often distinct vibratile cilia at their broad free end. The vibratile cilia of the epithelial cytoblasts, are larger and more extensively distributed in the fœtus than in the adult, as shown by Henle on the human epiglottis; and they are continued vibratile on the epithelium through the larynx, trachea, and the minutest ramifications of the bronchi, and the cells of the lungs, where the ciliated cytoblasts have the usual cylindrical form.

The epithelial cytoblasts continue cylindrical in the ducts of most glands, in the stomach, and along the whole intestine to the anus, where the epithelium abruptly unites with the flat-celled exterior epidermis, and they have the same cylindrical form in the interior of most of the uro-genital passages. In the female, however, the flat-celled epithelium lines the entire vagina, and the cylindrical cytoblasts with vibratile cilia, perceptible in the adult state, begin about the middle of the cervix uteri, and continue throughout the body of the uterus and along the Falopian tubes and their fimbriated terminations. The epithelium of serous membranes consists of flat cells, with a distinct central nucleus in each, and arranged in a tesselated form, as seen on the peritoneum, pleura, pericardium, tunica vaginalis testis, synovial membranes, and membranes of the brain. Vibratile cilia are more rarely observed on the epithelial cytoblasts of serous membranes, and exist on the lining membrane of the ventricles of the brain, and on the exterior peritoneal surface of the fimbriated ends of the Fallopian tubes. The epithelial cells detached from the parietes and ducts of secerning tubuli, and from other mucous surfaces, are observed isolated and mixed, like corpuscles, with the various secretions and excretions, as in mucus, saliva, lachrymal fluid, bile, and urine, and they appear to form the nuclei of morbid irritation, and the corpuscles of morbid secretions, in various pathological states.

Hairs, bristles, and spines are merely epidermic appendages, developed, like teeth, in highly vascular cutaneous sacs or follicles; they are formed by the successive aggregations of cytoblasts, and are gradually protruded from the piliferous follicles by the growth and elongation of their constituent cytoblasts, and by the addition of new layers to their expanded, soft and hollow base, the apex and shaft of the hair, or spine, being formed before the bulb, like the crown of the tooth before its fang. They are continuous, at their base, with the epidermis lining the enveloping follicles; they are composed of the same cells or cytoblasts, which are commonly arranged in rectilineal series; and they generally present a more dense exterior laminated cortical part, inclosing a loose granular medullary portion. The component cytoblasts are more round and loose at the soft, dilated base of the hairs, as in the rete mucosum; and they are compressed, elongated, and more compactly united, in the denser shaft of the hairs. By the rectilineal arrangement of the component cytoblasts, the hairs possess a fibrous structure, and greater elasticity and strength, they are more permeable to the oily secretion of the sebaceous follicles, and they exhibit a filamentous decomposition, often seen in the spontaneous longitudinal fissuring of the human hairs. The soft dilated bulbs of the hairs, beneath the cutis, are alone developed, and are confined to their follicles, in the smooth-skinned piscivorous cetacea. But in the rough-skinned herbivorous species of these animals, the shafts of the hairs are partly protruded from their follicles, like short, hard spines, and are especially developed on the upper lip, as they are also in amphibious carnivora. The almost horny epidermic integument of the herbivorous cetacea, has long been compared to the continuous horny hoofs covering the piliferous follicles and their contained hair-bulbs, on the feet of solidungula and ruminantia.

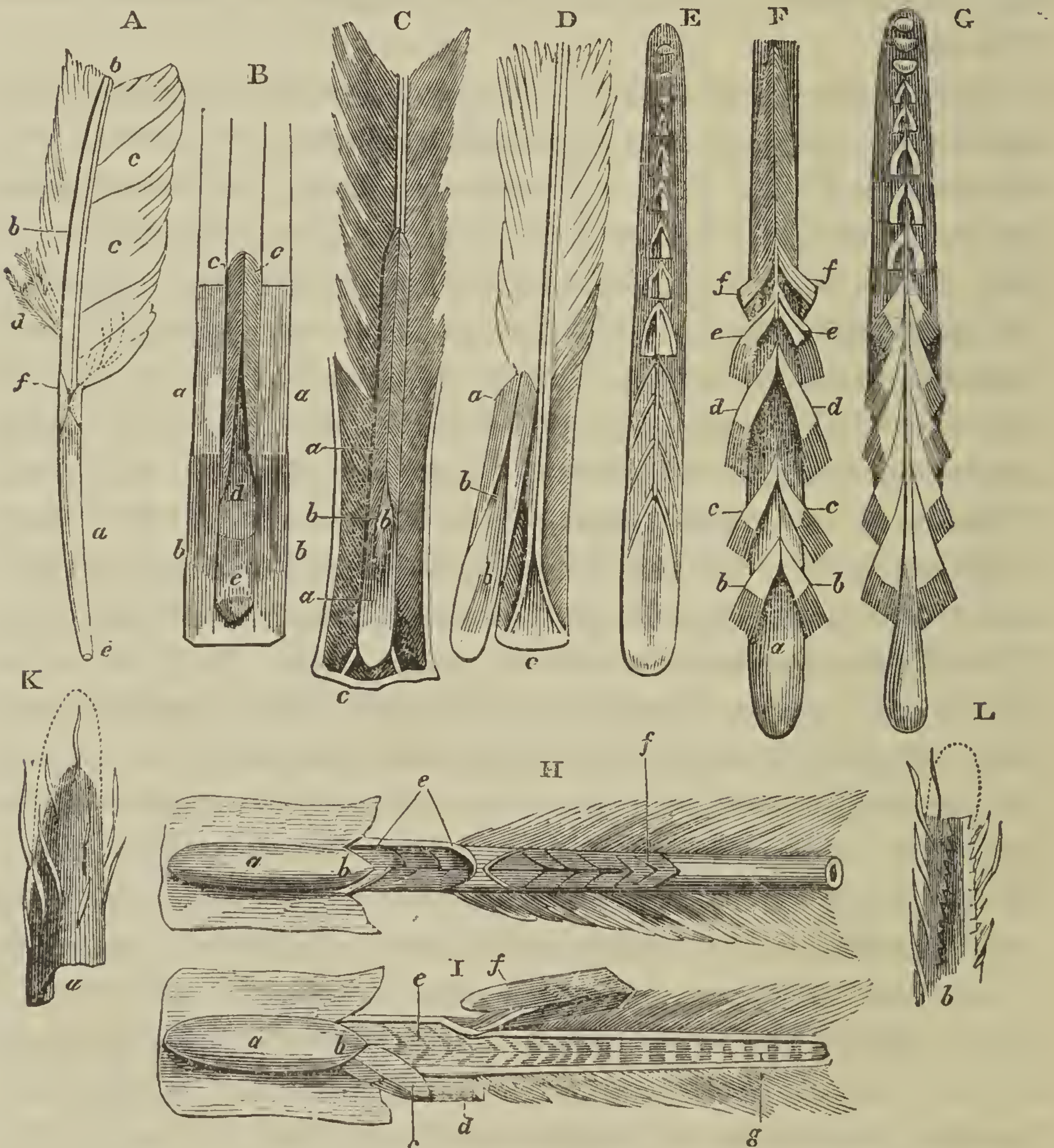
Hairs are successively reproduced in the same follicles, when shed periodically in mammalia, or when forcibly torn from their cavities, like the teeth of crocodiles in their alveoli. The hairs of mammalia grow and enlarge in their follicles, and are gradually protruded through their constricted apertures, by the addition of successive layers of epidermic cytoblasts, lineally aggregated, to the hollow interior and base of their soft, white, expanded bulb, and by the enlargement of the individual cytoblasts. The constituent cells are connected together, as in other epidermic parts, by the remains of the soft adhesive cytoblastema, which originally afforded them nutriment. By the great elongation and compression of the cells as they proceed outwards from the bulb, the shaft of the hair becomes much more narrow than the base from which it originates, and the fibrous structure is most apparent on the peripheral or cortical portion of the shaft. The fibrous composition of hair was described and figured by Leuwenhoek. The nuclei of the cytoblasts almost disappear, in the elongated cells forming, by their lineal aggregation, the ultimate filaments of hair; and the artificial separation of the constituent filaments, is rendered much more easy, by macerating the hairs in dilute muriatic acid, when they are seen to be disposed in a longitudinal, rectilineal and parallel order, from the bulb to the point of each hair. The filamentous structure and fibrous decomposition of hairs were familiar also to Hooke in 1667. The diameter of the ultimate fibrils of a hair is about the two thousandth of a line, and a human hair of one tenth of a line in thickness, has about two hundred and fifty fibrils in its mere diameter, and about fifty thousand in its entire calibre: so that these ultimate fibrils are finer than those of almost any other known tissue, from the great elongation and narrowing of their constituent cells, as they are drawn out into the shaft of the hair during growth; and hence the expanded bulb of the hair, where the cells are yet spherical and soft.

In the larger hairs, bristles, and spines there is generally a more compact, thin, dense cortical part, inclosing a loose cellular medullary portion, not perceptible in the human hairs; so that they more resemble the shafts of feathers destitute of lateral barbs. The highly vascular and sensitive hair-pulp in the long whiskers of carnivora, extends through the bulb into the shaft, and increases the sensibility of these parts, while it adds to their strength of attachment, and to their surface of increment. The nails and claws of mammalia and other vertebrata are composed of the same epidermic cells, and grow in reduplications of the skin forming compressed, curved follicles, like the cylindrical hairs and spines in their circular cavities. The successive strata of polygonal cells, which are most easily separable in the embryo and fœtus, are added, in lineal aggregations, to their covered base, and their compact, dense, free portion is gradually protruded from the compressed enveloping follicle. The constituent cytoblasts with their nuclei and fluid contents, are most distinct at the soft, white base, and at the inferior surface of the nails, and become compressed, flattened, and compactly agglutinated together on the upper surface and the protruded part, where the stratified arrangement is most apparent, and where the nuclei and contents of the cells have mostly disappeared. Layers of cells are secreted and added along the whole inferior attached, concave, lamellated surface, to compensate for the flattening and thinning of the upper convex strata of cells, first added from behind and from beneath, and thus to preserve the equal thickness and strength of the nail at its free, exposed part. The nails being thus only the thickened epidermis of the parts which support them, they adhere in the same manner as epidermis, to the subjacent sensitive and vascular laminated surface of the cutis, by means of the soft, homogeneous, adhesive cytoblastema which envelopes, nourishes, and unites together the growing component cells.

The anterior vertical portion of the hoofs of ruminantia and solidungula consists merely of a large curved nail, and the inferior horizontal portion, which is partially attached to the former along its anterior thick margin, is only the usual thickened epidermis, covering the lower surface of the toes. The vertical curved portion of the hoof, analogous to the human nail, embraces a large part of the anterior and lateral surface of the toe, is more deficient behind, and extends downwards beyond the plain of the inferior basilar plate, so as to defend the entire lower margin of the hoof, which is most subjected to pressure and attrition. In the feet of solidungula the entire anterior portion of the hoof is formed as a single investing independent nail, and extends beyond the inferior thickened epidermic plantar portion. The sharp, dense, compressed, curved claws of feline carnivora, are nails which almost invest the terminal phalanges of the toes, and have their base and its containing follicle supported by an osseous sheath; they are kept sharp at the point by the periodical shedding of their terminal laminæ. Even the permanent vaginiform horns of antilopes and other ruminantia, are formed and developed like conical nails around the tuberosities of the frontal bone, receiving their means of increment in their interior cavity and around their follicular base, like the tusk of an elephant, or the bill of a bird, a tortoise, or a cephalopod, or the conical shell of a gasteropod. And the solid nasal or frontal horn of the rhinoceros is developed from the subjacent periostium, like a large hair from its follicle, or like the horny coverings of the papillæ on the plantar surface of the feet in carnivora; and it exhibits the same fibrous structure and filamentous mode of decay, as in other epidermic parts composed of recti-lineal aggregations of cytoblasts. In these various forms of epidermic developments, the polyhedral form of the compressed cells, their nuclei and fluid contents, and their lineal arrangements, are most apparent in their primitive soft condition in the fœtus, or in the recently formed portions in the adult; and in their subsequent metamorphoses their internal fluid and nuclei disappear, the empty cells become elongated or flattened, with their interior parietes contiguous, they are agglutinated into laminæ by the remains of the cytoblastema, and their conformable stratified superposition is rendered more distinct.

The feathers of birds, like the hairs of mammalia, are epidermic developments contained in cutaneous follicles; they are provided with their vascular secreting pulp, their hollow bulbous base of increment, and their solid exposed shaft; and like them, they are composed of extravascular organized independent cells, or cytoblasts, which were already figured and described by Hooke, and by Leuwenhoek, as composing the entire microscopic structure of the feather. Like other epidermic structures, feathers are first formed and most developed on those parts where they are first and most required, and their horny composition and tubular structure are those best adapted to combine strength with lightness. The strong diaphanous tubular empty quill (147. A. *a.*) in the adult bird, is deeply imbedded in the cutaneous penniferous follicle, as the point of attachment and of nutriment of the feather, and contains only a few dried remains of the primitive secreting pulp-cells. The tapering light elastic conical shaft (147. A. *f. b.*) is occupied internally with white dried aeriferous cytoblasts, which were described before the time of Leuwenhoek, and gives a firm support to the two unequal sides of the vane (147. A. *c. d.*). The vane is composed of barbs (147. A. *d.*) or laminæ placed vertically to afford the greatest resistance in flight, closely applied to each other, continued from the sides of the shaft, and connected together by barbules developed from each side of their dorsal or exterior margin. The barbules again develope, from their margins, minute curved, hooked filaments, or barbulinæ, to complete this delicate structure for hooking together and uniting the barbs into a continuous membrane, as shown by Hooke, who carefully investigated, described, and figured this complex mechanism in 1667, and accurately compared each barbule, with its barbulinæ, to the structure of an entire feather. In most feathers the proximal part of the vane (147. A. *d.*) has its barbs and barbules long, loose and floating, so as to form a compact downy mantle next the skin of the bird, to retain the high temperature of the body. In the rest of the vane the barbs are more firm, straight, regular and united, to assist in flight, or to protect the body.

Fig. 147.



The parts of the feather, as shown by Dutrochet, Blainville, and F. Cuvier, are at first formed within a thick closed epidermic capsule (147. B.) embracing in its axis two concentric striated membranes, (147. B. *b. d.*), and a highly vascular, secreting, formative pulp (147. B. *d. e.*), and contained in a deep penniferous follicle. This exterior epidermic capsule, perforated below by the vessels and nerves of the organized pulp, elongates, opens above, and allows the newly formed parts of the feather to escape from the opening of the cutaneous follicle. This general extra-vascular enveloping capsule, (147. C. c.), is entirely composed of strata of large flattened cytoblasts, which grow by their independent vitality, are united by their cytoblastema, and give a necessary brittleness to the texture of this deciduous membrane. On cutting open the exterior capsule of the young feather, the two more delicate tonics are seen investing the pulp, and connected together by numerous septa; the soft, newly formed barbs, (147. B. *c. c.*) moulded between these septa, are thus found folded around the central organized matrix, being developed in a polythalamous cavity filled with the granular secretion of the vascular pulp. The pulp developes a series of superimposed conical capsules, and traverses their axis in a continuous canal, as seen in the annexed figures from F. Cuvier (147. E. F. G.). The dense tubular elastic quill is formed by the meeting of the edges of the exterior horny dorsal lamina of the shaft, after the completion and convergence of the two sides of the vane; and an exterior opening, or upper umbilicus, is left at this point for the admission of air to the interior and cells of the quill and the shaft. The membranous cells (147. K. L.), disengaged from the distal extremity of the organized pulp, and occupying at first the cylindrical cavity of the folded barbs, are successively detached, exposed, and lost by the unfolding of the barbs, and the rest are confined and retained, dried, and collapsed, within the closed tubular quill, after the shaft is completed.

The large polyhedral pith-cells of the growing shaft contain, at first, a fluid substance; they are provided each with a distinct nucleus adhering to its inside, and within the nuclei are seen one or two comparatively large nucleoli; the cells are easily separable from each other; they have firm exterior parietes, and in the adult state, like the few large cells of the quill, they contain only air, and have nearly lost all traces of their nuclei. As the internal constituent cytoblasts of the shaft-pith are successively derived from around the apex of the contained central organized pulp, they are most developed towards the outer dorsal convex part of the shaft, and are smallest near the central cavity, which is indicated only by an inferior longitudinal groove in the adult expanded feather. More nearly in contact with the formative matrix, indeed, are found mere granular nuclei, contained in a fluid cytoblastema; and these organized, though extravascular, independent nuclei, pass through the ordinary phases of development and growth, seen in other epidermic and epithelial cytoblasts. These epidermic cells composing the white friable corky pith of the shaft, were accurately described by Hooke in 1667, and Leuwenhoek described and figured the cytoblasts, or globules, composing the barbs.

The formation of a distinct, thin, dense, interior epidermic layer, in the concavity of the growing shaft, and around the exterior surface of the secreting matrix (147. H. I. *a. b.*) completes the inferior concave surface of this part of the feather, and prepares for its gradual protrusion, with the perfected and unfolding barbs continuous with its sides. On opening the organized pulp (147. D. *b. b.*), innumerable vessels, turgid with red blood, are seen forming a continuous network over every part of its interior parietes, and their trunks are observed entering the convex conical part of its base where a terminal opening or inferior umbilicus is left in the adult quill (147. A. *e.*). The outer strong elastic layer forming the dorsal fibrous covering of the shaft, between the outer ends of the septa, or barbiferous cells, is early developed, and originates from cytoblasts, which undergo changes very similar to those which give origin to the minute fibres of cellular tissue. From their primitive rounded form, these cells are observed to elongate, to become flattened, and gradually to subdivide each into numerous longitudinal fibres; their nuclei disappear, their parietes become absorbed or fissured, and they at length constitute the compact horny fibrous covering of the dorsum of the shaft, and the entire parietes of the quill, which is merely a cylindrical continuation of that portion of the feather. The inferior grooved surface of the shaft is covered by a similar deposition of granular independent animated cells, with their nutrient fluid cytoblastema between the lower ends of the grooved barbiferous septa, or complicated cavities in which the apparatus of the vane is moulded. On examining even the minutest parts of the barbules of feathers, the constituent elongated compressed angular cytoblasts, compactly and symmetrically arranged, and provided with persistent central nuclei, are distinctly perceptible. A second shaft, furnished with all the apparatus of the vane, is generally more or less developed from the superior umbilicus or distal opening of the quill, and this supplementary shaft sometimes, as in the emeu, equals in length that of the primary feather. The rudiment even of a third shaft is sometimes developed from the feather, and the entire plumage of a bird is sometimes renewed once or twice in a single season. But notwithstanding the endless diversity of form and the intricate structure of these organs, and the remarkable changes they undergo during their development, growth, and moulting, they present only a more complex form of the ordinary insensible, extravascular, epidermic tissue, forming the exterior integument of most organized bodies.

In the simple organizations of the lowest animals, the difference is less marked, between the exterior cutaneous and the interior mucous coats, and between the epidermic and the epithelial developments they form on their surface; and as most of them are inhabitants of an aquatic medium, their epidermic covering generally retains the soft condition of a rete mucosum, or of a mucous deposit, as seen in the naked forms of radiated, helminthoid, and molluscous animals. It is shed in flocculi from poriphera, and in larger pellicles from the surface of many zoophytes, as lobularia, and its constituent cytoblasts were observed by Gäde in acalepha. In many vaginated forms of polygastric and polypipherous animals, it composes a firm, elastic, often articulated, almost horny sheath, over the entire surface of the true skin; and in the entomoid and testaceous animals, it becomes consolidated by the addition of various earthy materials, to compose their enveloping extravascular skeletons. Its granular nuclei are constantly pouring from the vascular secreting surface of the cutis, its condensed accumulations adhere to the skin by means of the cytoblastema, and these accumulated epidermic masses are periodically thrown off from the body in the articulata, but are consolidated, collected, and permanently retained in the testaceous mollusca and radiata. The resplendent hairs of halithea, the setæ of annelides, and the agglutinating matter of their tubes, the down and hairs of larvæ, and those common on adult insects, arachnida, and crustacea, the byssus of conchifera, the horny opercula of gasteropods, the horny mandibles of cephalopods, the lingual spines of many mollusca, the gastric teeth of aplysia, the spines of the gizzard of insects, the gastric plates of bulla, and the animal matter of all testaceous coverings, may be considered as parts of the same epidermic or epithelial tissue, having the same extravascular and cytoblastic character, and the same organization and independent vitality.

The tegumentary organs of the vertebrata are closely related to the temperature of the body, and to the density of the surrounding medium, those of the warm-blooded classes being slow conductors of caloric, in order to preserve the high temperature of their body, and those of the cold-blooded being indifferent in their conducting power, as they are also in most invertebrata. The sensitive vascular skin of fishes, is thick, soft, gelatinous, and closely connected by tendinous intersections with the subjacent muscular system. The cuticle, as in the naked aquatic mollusca, forms a thin, soft layer; and by its periodical shedding, the lively colours of the inferior loose strata of cytoblasts, or rete mucosum, are allowed to shine more distinctly through the pellucid scales, and this increased brilliancy of colour is most marked at the spawning season. The imbricated scales of fishes, which are wanting in the cyclostome and very minute in the plagiostome species, but generally cover their surface, are consolidated by phosphate of lime, detected also in the hairs of mammalia; and they grow, like the human nails, or the wing scales of lepidopterous insects, by successive layers added by the squamiferous follicles of the cutis, in which they are fixed.

From the soft, thin, and granular condition of the newly formed epidermic and epithelial coverings of membranes, the secretion of glandular tubuli, and the respiration of pulmonary cells, or branchial laminæ, are easily effected through these coverings. And from the necessity for free respiration by the entire cutaneous surface of the body in the amphibia, their highly sensitive and vascular cutis is destitute of scales; it is covered only with a thin, soft epidermis, which is cast rapidly and frequently, that of the frog and triton being apparently shed every month. Their copious exterior secretions, perhaps, also demand a higher cutaneous oxygenation and a thinner epidermic covering. The epidermis of the triton is shed in an entire piece, as in serpents. On the surface of the tough, thick, fibrous, papillated cutis of ophidian and saurian reptiles, the soft rete mucosum, composed of newly-formed cytoblasts, generally presents the most intensely and lively coloured pigment-cells, which fade or die before they are shed with the concrete outer layer of epidermis. As the apparent scales and scuta are only elevated papillæ or tubercles of the vascular secreting cutis, sometimes partially imbricated, the epidermis passes continuously over them, and is thus cast from the entire body without perforations or scales, and even from the united transparent eye-lids or conjunctiva of serpents, as from the compound eyes of articulata. The tortoise-shells, or epidermic plates, covering the osseous elements of the carapace and plastron of chelonia, are permanent accumulations of cytoblasts, formed in successive and increasing layers from the subjacent vascular periosteum, like the nasal horns of the rhinoceros, or the permanent vaginiform horns of ruminantia; and the limits of the successive layers of growth, are here commonly indicated by peripheral ridges on the exterior of the plates, as on the shells of conchifera and of gasteropods.

The sparkling and resplendent surface of most fishes, accords with the liquid element and its pebbled bed; the dull and sombre surface of most amphibia and serpents, accords with their concealed habitats; and the more lively colours of many climbing ophidia and lacertine sauria, are adapted to their arboreal life. The mutable colours of the chamælion, conceal it from its insect prey; the dark rough surface of crocodilian sauria, conceal them on the muddy banks of rivers, or among the decayed trunks of fallen trees; the dark dull surface of most terrestrial chelonia corresponds with their lurking and burrowing habits; the lustre, transparency, and mottled brown colours of marine turtles, pervading the whole substance of their large, permanent, epidermic plates, resemble those of the dark fuci, on which they rest and feed. The parasitic pigment-cells of epidermic cytoblasts, are little developed amid the snows and darkness of arctic regions, where albino peculiarities are naturalized, as in the wild swan, the snowy owl, the alpine hare, the arctic fox, the polar bear. Dull and sombre hues best suit nocturnal animals, as moths and owls, rats and mice, bats and lemurs; and the darkest colours conceal the inhabitants of burrows and subterranean caves, as beetles, toads, and moles, and the huge inhabitants of the dark abyss, as walruses, seals, and cetacea. The most lively and varied colours, and the brightest metallic lustres, are developed in the diurnal species of tropical climes, as in parrots and cockatoos, humming birds, and birds of paradise; and the hues appear often to be regulated by those of the accompanying vegetation. The metallic lustre, so rare in mammalia, is splendid in the chrysochloris. The reddish-brown fleece of lions and pumas, caracals and tigers, and most feline inhabitants of the deserts, resembles the decayed leaves, or the light of the setting sun, or the sandy plains on which they lie in watch for their prey. So that the properties of these extravascular parts, have extensive relations to the internal economy of animals, and to surrounding nature.

The colours of the tegumentary parts of animals, depending upon living parasites in the body of the epidermic cells, are most distinct in the plump condition of these in the rete mucosum, and are alike obvious in the chick in ovo, on the fœtus in utero, in the developing feather yet concealed in its thick sheath and deep cutaneous follicle, and in the hairs of subcutaneous cysts, to which the chemical influence of light has never penetrated. Indeed the entire structure, properties, and forms of the tegumentary parts of organized beings, are regulated by laws as simple and uniform as those of the most essential organs of vegetative life, and they are most intimately connected with the living habits and the entire history of the species.

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